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Docket No.
JEL 31207

Total Pages in this Submission
3

jc715 U.S. PTO 06/29/00

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

TRANSMISSION/RECEPTION APPARATUS

jc856 U.S. PTO 09/605862 06/29/00

and invented by:

Hiroaki SUDO

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: ______

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below

2. ☒ Specification having 25 pages and including the following:

   a. ☒ Descriptive Title of the Invention
   b. ☐ Cross References to Related Applications *(if applicable)*
   c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   d. ☐ Reference to Microfiche Appendix *(if applicable)*
   e. ☒ Background of the Invention
   f. ☒ Brief Summary of the Invention
   g. ☒ Brief Description of the Drawings *(if drawings filed)*
   h. ☒ Detailed Description
   i. ☒ Claim(s) as Classified Below
   j. ☒ Abstract of the Disclosure

P01ULRG/REV04

UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity) *(Only for new nonprovisional applications under 37 CFR 1.53(b))*	Docket No. **JEL 31207**
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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   - a. ☒ Formal Number of Sheets 10
   - b. ☐ Informal Number of Sheets ______
4. ☒ Oath or Declaration
   - a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
   - b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   - c. ☒ With Power of Attorney ☐ Without Power of Attorney
   - d. ☐ <u>*DELETION OF INVENTOR(S)*</u>
     Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Computer Program in Microfiche *(Appendix)*
7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   - a. ☐ Paper Copy
   - b. ☐ Computer Readable Copy *(identical to computer copy)*
   - c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers *(cover sheet & document(s))*
9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*
10. ☐ English Translation Document *(if applicable)*
11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☐ Certificate of Mailing
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Accompanying Application Parts (Continued)

15. ☒ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☐ Additional Enclosures *(please identify below)*:

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	6	- 20 =	0	x	$18.00	$0.00
Indep. Claims	2	- 3 =	0	x	$78.00	$0.00
Multiple Dependent Claims (check if applicable) ☐						$0.00
					BASIC FEE	$690.00
OTHER FEE *(specify purpose)*						$0.00
					TOTAL FILING FEE	$690.00

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☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **19-4375** as described below. A duplicate copy of this sheet is enclosed.

- ☐ Charge the amount of as filing fee.
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- ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Signature

Dated: **June 29, 2000**

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SPECIFICATION

Title of the Invention :

TRANSMISSION/RECEPTION APPARATUS

Inventor :

Hiroaki SUDO

TRANSMISSION/RECEPTION APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a transmission/reception apparatus, and more particularly, to a transmission/reception apparatus that assigns a spread transmission signal for a subcarrier for each spread signal to perform frequency division multiplexing in a mobile communication, and thereby performs radio communications in a combination system of OFDM/TDD and CDMA, and a transmission diversity method for such an apparatus.

Description of the Related Art

In a CDMA communication, interference between spreading codes takes place in multipath environment, and an error rate characteristic deteriorates. Meanwhile, as a communication system resistant to the interference between spreading codes, there is known an OFDM communication using guard intervals. Therefore as a next generation system, attention is drawn to an OFDM-CDMA system radio communication which provides multicarrier in the CDMA communication, assigns a subcarrier signal for each chip, and thereby performs frequency division multiplexing to transmit signals.

In the OFDM-CDMA communication, a plurality of signals are spread with different non-correlative spreading codes, and one spread signal is assigned one

subcarrier. When the spreading codes are completely orthogonal, it is possible to completely remove signals except required signals by despreading processing in receiving the signals even if the signals are multiplexed greatly.

The following explains a conventional OFDM-CDMA transmission/reception apparatus using FIGS.1 and 2. FIG.1 is a block diagram illustrating a schematic configuration of the conventional transmission/reception apparatus, and FIG.2 is a schematic diagram illustrating one example of subcarrier assignments in a conventional OFDM-CDMA communication.

In a transmission system in FIG.1, spreading section 1 multiplies transmission signals 1 to n respectively by spreading codes 1 to n to perform spreading processing. Herein a spreading factor is assumed to be k.

Addition section 2 adds spread transmission signals, and Serial-Parallel; S/P converter 3 converts single-sequence signals into plural-sequence signals. Herein added spread transmission signals are divided for each spread signal, and spread transmission signals 1 to n are disassembled into the first to kth chips for each spread signal (chip).

IFFT processing section 4 performs Inverse Fourier Transform processing on the plural-sequence signals, and at this point, assigns one subcarrier for one chip data

signal sequence to process frequency division multiplexing.

That is, the number of subcarriers matches with the spreading factor, and herein is k. In addition, it is assumed that subcarrier 1 is assigned for first chips of transmission signals 1 to n, and subcarrier k is assigned for kth chips of transmission signals 1 to n. In other words, chip data sequences are subjected to the frequency division multiplexing. FIG.2 illustrates this aspect. Antenna 5 performs transmission and reception of radio signals.

In a reception system, FFT processing section 6 performs Fourier Transform processing on a received signal to obtain each subcarrier signal (chip data signal sequence). Compensation sections 7 are provided for each subcarrier, and perform compensation processing such as phase compensation on respective subcarrier received signals.

Parallel-Serial; P/S converter 8 converts the plural-sequence signals into the single-sequence signals, specifically rearranges each subcarrier signal for one chip, outputs at time t1 the first chip of a signal obtained by multiplexing spread transmitted signals 1 to n, outputs at time t2 the second chip of the signal obtained by multiplexing spread transmitted signals 1 to n, and then sequentially outputs at time tk the kth chip of the signal obtained by multiplexing spread

transmitted signals 1 to n.

Despreading section 9 multiplies received signals, each of which is converted into the single-sequence signal, by respective spreading codes 1 to n, and obtains only signals spread with the codes to perform despreading.

However the conventional transmission/reception apparatus has the following problem. That is, in the multipath environment, each subcarrier signal is affected by fading variation independently, causing a case that received amplitudes are different between subcarrier signals as illustrated in FIG.3.

In the OFDM-CDMA communication, since one subcarrier is assigned for each chip assignment position of each spread transmission signal, i.e., one subcarrier is assigned for one chip, to perform the frequency division multiplexing, a deviation in received amplitude of each subcarrier signal directly becomes a deviation in received amplitude of the spread signal, and as a result, the orthogonality deteriorates.

That is, spreading codes are selected so that each spreading code is orthogonalized to each other. However there is the assumption that amplitudes of the spreading codes are constant, and therefore the orthogonality deteriorates when divinations are generated in received amplitudes of spreading codes.

For example, the correlation of spread signal

sequence RX [1, -1, 1, 1] with spreading code sequence TX [-1, -1, 1, -1] is as follows:

$$RX \cdot TX = [1, -1, 1, 1] \cdot [-1, -1, 1, -1]$$
$$= 1 \times (-1) + (-1) \times (-1) + 1 \times 1 + 1 \times (-1)$$
$$= 0$$

where the orthogonality is confirmed.

Herein assume that amplitude divination is generated in spreading code sequence RX, and that RX becomes RX'[3, -0.1, 0.2, 1]. In this case, the correlation is as follows:

$$RX' \cdot TX = [3, -0.1, 0.2, 1] \cdot [-1, -1, 1, -1]$$
$$= 3 \times (-1) + (-0.1) \times (-1) + 0.2 \times 1 + 1 \times (-1)$$
$$= -3.7$$

where the orthogonality deteriorates.

Thus in the multipath environment, when the orthogonality between spreading codes deteriorates, other signal components remain as noise components corresponding to deterioration of the orthogonality, and thereby the error rate characteristic deteriorates. Since the noise components are increased as the number of multiplexed signals is increased, the deterioration of the error rate characteristic is proportional to the number of multiplexed signals, and as a result, the extent of deterioration is increased as the number of multiplexed signals is increased.

Generally in the radio communication system, since the error rate is controlled to be below a predetermined

level, the number of signals to be multiplexed is decreased to prevent the deterioration of the error rate characteristic, and thereby the transmission capacity is decreased.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a transmission/reception apparatus that decreases an amplitude difference between subcarrier signals to maintain the orthogonality between spreading codes, and thereby enables improved transmission efficiency in the multipath environment.

It is a subject of the present invention to select a branch providing the largest received amplitude for each subcarrier at the time of reception, and transmit only subcarrier signals selected for each branch at the time of transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawing wherein one example is illustrated by way of example, in which;

FIG.1 is a block diagram illustrating a schematic configuration of a conventional transmission/reception apparatus;

FIG.2 is a schematic diagram illustrating one example of subcarrier assignments in a conventional

OFDM-CDMA communication;

FIG.3 is a schematic diagram illustrating another example of subcarrier assignments in a conventional OFDM-CDMA communication;

FIG.4 is a block diagram illustrating a schematic configuration of a transmission/reception apparatus according to a first embodiment of the present invention;

FIG.5 is a block diagram illustrating a schematic configuration of a diversity control section in the transmission/reception apparatus according to the first embodiment of the present invention;

FIG.6A is a schematic diagram illustrating one example of subcarrier assignments of transmission signals for branch 1 according to the first embodiment of the present invention;

FIG.6B is a schematic diagram illustrating one example of subcarrier assignments of transmission signals for branch 2 according to the first embodiment of the present invention;

FIG.6C is a schematic diagram illustrating one example of subcarrier assignments of received signals according to the first embodiment of the present invention;

FIG.7 is a block diagram illustrating a schematic configuration of a transmission/reception apparatus according to a second embodiment of the present invention;

FIG.8 is a block diagram illustrating a schematic configuration of a diversity control section in the transmission/reception apparatus according to the second embodiment of the present invention;

FIG.9A is a schematic diagram illustrating one example of subcarrier assignments of transmission signals for branch 1 according to the second embodiment of the present invention;

FIG.9B is a schematic diagram illustrating one example of subcarrier assignments of transmission signals for branch 2 according to the second embodiment of the present invention;

FIG.9C is a schematic diagram illustrating one example of subcarrier assignments of received signals according to the second embodiment of the present invention; and

FIG.10 is a block diagram illustrating a schematic configuration of a diversity control section in the transmission/reception apparatus according to a third embodiment of the present invention;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described below with reference to accompanying drawings.

(First embodiment)

A transmission/reception apparatus according to this embodiment selects a branch providing the largest

received amplitude for each subcarrier at the time of reception, and transmits only subcarrier signals selected for each branch at the time of transmission.

The transmission/reception apparatus according to this embodiment is explained below using FIGS.4 to 6. FIG.4 is a block diagram illustrating a schematic configuration of the transmission/reception apparatus according to the first embodiment of the present invention, FIG.5 is a block diagram illustrating a schematic configuration of a diversity control section in the transmission/reception apparatus according to the first embodiment of the present invention, and FIG.6 is a schematic diagram illustrating one example of subcarrier assignments of transmission signals and received signals according to the first embodiment of the present invention. In addition, it is assumed herein that the number of branches is 2.

In a transmission system in FIG.4, spreading section 101 multiplies transmission signals 1 to n respectively by spreading codes 1 to n to perform spreading processing. Herein a spreading factor is assumed to be k. Addition section 102 adds spread transmission signals, and S/P conversion section 103 divides added spread transmission signals for each spread signal, and disassembles spread transmission signals 1 to n, for each spread signal, i.e., into the first to kth chips.

Selectors 104 are provided for each subcarrier, and switched using as switching control an instruction from diversity control section 111 described later to output an input spread signal to either of IFFT processing section 105 for branch 1 described later or IFFT processing section 106 for branch 2 described later.

IFFT processing section 105 is the IFFT processing section for branch 1, and assigns one subcarrier for one chip data signal sequence to process the frequency division multiplexing. Similarly IFFT processing section 106 is the IFFT processing section for branch 2, and assigns one subcarrier for one chip data signal sequence to process the frequency division multiplexing.

Antenna 107 performs transmission and reception of radio signals for branch 1, and antenna 108 performs transmission and reception of radio signals for branch 2.

Meanwhile in a reception system, FFT processing section 109 is the FFT processing section for branch 1, and performs Fourier Transform processing on a received signal to obtain each subcarrier signal (chip data signal sequence). Similarly FFT processing section 109 is the FFT processing section for branch 2, and performs Fourier Transform processing on a received signal to obtain each subcarrier signal (chip data signal sequence).

Diversity control section 111 detects a received amplitude for each subcarrier in each branch, and selects

a branch providing the largest received level for each subcarrier. The selection result is output, as a switching control signal, to each selector 104 in the transmission system and each selector 112 in the reception system described later. The configuration of diversity control section 111 is described later.

Selectors 112 are provided for each subcarrier, and switched using as switching control an instruction from diversity control section 111 to output, for each subcarrier, the received signal from either of FFT processing section 109 for branch 1 or FFT processing section 110 for branch 2 to corresponding compensation section 113 (described below).

Compensation sections 113 are provided for each subcarrier, and perform compensation processing such as phase compensation on respective subcarrier received signals. P/S conversion section 114 rearranges each subcarrier signal for one chip, outputs at time t1 the first chip of a signal obtained by multiplexing spread transmitted signals 1 to n, outputs at time t2 the second chip of the signal obtained by multiplexing spread transmitted signals 1 to n, and then sequentially outputs at time tk the kth chip of the signal obtained by multiplexing spread transmitted signals 1 to n.

Despreading section 115 multiplies received signals, each of which is converted into the single-sequence signal, by respective spreading codes 1 to n,

and obtains only signals spread with the codes to perform despreading.

The configuration of diversity control section 111 is next explained using FIG.5. In FIG.5, square sum calculation sections 201 are provided for each subcarrier for each branch, and calculate $\sqrt{(I2+Q2)}$ of the respective received signal to calculate a received amplitude. Comparison section 202 determines which branch provides the largest received amplitude, for each subcarrier, by comparing. The information indicative of either branch selected by the determination is output as the switching control signal to selectors 104 in the transmission system and selectors 112 in the reception system for each subcarrier.

The operation of the transmission/reception apparatus with the above-mentioned configuration is next explained.

In the transmission system, transmission signals 1 to n are spread with respective spreading codes 1 to n in spreading section 101, added to be single-sequence signals in addition section 102, and divided into subcarrier signals (1 to k) of which the number of is the same as that of spreading factor (herein, k) in S/P conversion section 103 for each chip.

In other words, when the spreading factor of each transmission signal is 16, a signal sequence comprised of the first chip of each spread transmission signal is

carried with subcarrier 1, then sequentially subcarriers are assigned for respective chip positions in the transmission signals, and a signal sequence comprised of the 16th chip of each transmission signal is carried with subcarrier 16.

Each subcarrier transmission signal is output to either of IFFT processing section 105 or IFFT processing section 106 by selector 104 of which the switching is controlled by diversity control section 111, to be IFFT-processed, and then transmitted from antenna 107 (branch 1) or antenna 108 (branch 2).

Thus, in the transmission system, a signal is transmitted for each subcarrier through a branch that provides a larger received amplitude in the reception system. FIGS.6A and 6B illustrates examples. FIG.6A illustrates one example of subcarrier groups transmitted through branch 1, and FIG.6B illustrates one example of subcarrier groups transmitted through branch 2.

As illustrated in the figures, since each subcarrier signal is transmitted through either branch, a reception side can obtain all the subcarrier signals by combining signals from both branches.

Meanwhile in the reception system, received signals received by antenna 107 (branch 1) and antenna 108 (branch 2) are respectively FFT-processed in FFT processing sections 109 and 110.

With respect to each received signal for each

subcarrier in both branches, a received amplitude is calculated in diversity control section 111, and the amplitude level of the received signal from one branch is compared with that of the received signal from another branch to determine a larger level for each subcarrier. The branch selected for each subcarrier is output to selectors 104 in the transmission system and selectors 112 in the reception system.

FFT-processed received signals are selected by selectors 112 provided for each subcarrier, to output either signal of branch 1 or branch 2 providing a larger received amplitude for each subcarrier. This state is illustrated in FIG.6C. For each subcarrier, in other words, for each frequency band, branch signals each with the larger received amplitude are selected, whereby it is possible to cancel subcarrier signals with extremely low levels.

Selected subcarrier received signals are compensated in, for example, phase rotations, in respective compensation sections 113, rearranged per chip basis in P/S conversion section 114 to be converted into single-sequence signals, despread with respective spreading codes in despreading section 115, and thereby received signals 1 to n are obtained.

Thus, according to this embodiment, by selecting a branch providing a larger received amplitude for each subcarrier at the time of reception, and transmitting

only subcarrier signals selected for each branch at the time of transmission, the amplitude deviation in subcarrier received signals is decreased, and thereby it is possible to maintain the orthogonality between spreading codes, and to prevent the transmission efficiency from being lowered in the multipath environment.

(Second embodiment)

A transmission/reception apparatus according to this embodiment has the similar configuration with that in the first embodiment, and performs transmission gain control.

The transmission/reception apparatus according to this embodiment is explained below using FIGS.7 to 9. FIG.7 is a block diagram illustrating a schematic configuration of the transmission/reception apparatus according to the second embodiment of the present invention, FIG.8 is a block diagram illustrating a schematic configuration of a diversity control section in the transmission/reception apparatus according to the second embodiment of the present invention, and FIG.9 is a schematic diagram illustrating examples of subcarrier assignments of transmission signals and received signals according to the second embodiment of the present invention. In addition the same sections as in the first embodiments are given the same marks to omit specific explanations thereof.

In FIG.7, divider 401 divides subcarrier signals by respective division coefficients set for each subcarrier corresponding to a received amplitude level of each subcarrier signal in the reception system to equal an amplitude level of each subcarrier signal.

When such transmission amplitude control taking propagation path into consideration is performed, transmission signals are weighted in advance for each subcarrier, and transmitted with amplitude levels illustrated in FIGS.9A and 9B. FIG.9A illustrates one example of subcarrier assignments of transmission signals to be transmitted from branch 1, and FIG.9B illustrates one example of subcarrier assignments of transmission signals to be transmitted from branch 2.

Diversity control section 402 calculates an average amplitude level of the received signals from branches selected for each subcarrier, and further calculates a ratio of the received amplitude level to the average amplitude level for each subcarrier.

In FIG.8, averaging section 501 calculates the average amplitude level of signals received from either branch selected in comparison section 202 for each subcarrier. Calculation section 502 calculates for each subcarrier the ratio of the amplitude level of the received signal selected for each subcarrier to the average amplitude level calculated in averaging section 501, and outputs the resultant as a division coefficient

to respective divider 401.

In addition, the above-mentioned division coefficient W(k) is (output from square sum calculation section)/(output from averaging section 501), and expressed with the following equation 1, where Ik is a received I signal in subcarrier k, Qk is a received Q signal in subcarrier k, N is the number of all subcarriers, and k is the subcarrier number.

$$W(k) = \sqrt{\frac{{I_k}^2 + {Q_k}^2}{\frac{1}{N}\sum_{k=1}^{N}({I_k}^2 + {Q_k}^2)}} \qquad \text{eq.1}$$

When the above-mentioned transmission amplitude control is performed, since the reception side receives signals that are weighted prior to the transmission corresponding to propagation path condition, received subcarrier amplitude levels are made constant as illustrated in FIF.9C, and thereby it is possible to cancel the amplitude deviation efficiently.

Thus according to this embodiment, the transmission amplitude control is performed for each subcarrier signal corresponding to the received amplitude, and weighting is performed prior to the transmission with propagation path condition taken into consideration, whereby it is possible to make amplitude levels constant levels at the reception side, and therefor to decrease the received amplitude deviation.

(Third embodiment)

The transmission/reception apparatus according to

this embodiment has the similar configuration with that in the second embodiment, and sets an upper limit in the amplitude level (gain) to reduce peak power.

The transmission/reception apparatus according to this embodiment is explained below using FIG.10. FIG.10 is a partial block diagram illustrating a schematic configuration of a diversity control section in the transmission/reception apparatus according to the third embodiment of the present invention. In addition, the same sections as in the second embodiment are given the same marks to omit specific explanations thereof.

In FIG.10, comparison sections 701 are provided for each subcarrier, compare respective division coefficients W(k) calculated in respective calculation sections 502 with the upper limit of amplitude that is a preset arbitrary number, and output respective comparison results to selector 702.

Each of selectors 702 switches between input sources using an output signal from respective comparison section 701 as a switching control signal to output the division coefficient itself when the division coefficient is equal to or less than the upper limit, and to output the upper limit when the division coefficient exceeds the upper limit.

Thus, according to this embodiment, the amplitude level is controlled not to exceed a predetermined upper limit, and it is thereby possible to reduce peak power.

In addition in this embodiment, it is possible to achieve both the peak power reduction and improved transmission efficiency by varying the upper limit of amplitude adaptively corresponding to the number of subcarriers.

While the above-mentioned first to third embodiments explain the case where the number of branches is two, the application of the present invention is not limited to this condition, and the number of branches may be arbitrary. Further the numbers of subcarriers and spreading codes may be arbitrary also.

Moreover while the above-mentioned first to third embodiments explain the case of using selection diversity as a kind of diversity, the present invention is not limited to the above-mentioned condition, and is applicable to cases of using the other kinds of diversities such as equal-gain combining diversity and maximal-ratio combining diversity, and the same effects may be obtained.

In addition the transmission diversity explained in the above-mentioned first to third embodiments improves the error rate characteristic, but does not improve the transmission efficiency when used in an ordinary OFDM communication. That is due to the fact that in the ordinary OFDM communication in which one transmission signal is carried with one subcarrier, when two or more transmission signals are carried with one

carrier, signals except desired signals provide interference in each subcarrier signal even if the received amplitude of each subcarrier is constant. Therefore the presence of interference signals with the same levels as desired signals makes communication difficult.

The transmission/reception apparatus according to the present invention adopts a configuration having a reception section that receives radio signals comprised of a plurality of carrier signals, subjected to frequency division multiplexing, from each of a plurality of branches, a branch selection section that calculates received amplitude levels for each subcarrier signal in all the branches, and detects a branch providing a largest received amplitude for each carrier signal, a demodulation section that despreads a selected carrier signal with a predetermined spreading code to obtain data, and a transmission section that performs frequency division multiplexing using the plurality of carrier signals to transmit for each subcarrier from the branch selected in the branch selection section.

According to this configuration, by selecting branches each providing a larger received amplitude for each subcarrier at the time of reception, and transmitting only subcarriers selected for each branch at the time of transmission, the amplitude deviation in subcarrier received signals is decreased, and thereby

it is possible to maintain the orthogonality between spreading codes, and to prevent the transmission efficiency from being lowered in the multipath environment.

The transmission/reception apparatus according to the present invention adopts the configuration where the transmission section has an average level calculation section that calculates an average received amplitude level of selected carrier signals, a division coefficient calculation section that calculates a ratio of a received amplitude level of one of the selected subcarrier signals to the average received amplitude level for each carrier, and a division section that divides a transmission signal immediately before being subjected to the frequency division multiplexing by the ratio for each carrier signal.

According to this configuration, transmission amplitude control is performed for each subcarrier signal corresponding to the received amplitude, and weighting is performed prior to the transmission with propagation path condition taken into consideration, whereby it is possible to make amplitude levels constant levels at the reception side, and therefor to decrease the received amplitude deviation.

The transmission/reception apparatus according to the present invention adopts the configuration where the division coefficient calculation section holds an

arbitrary threshold, compares a calculated ratio with the threshold, and outputs the threshold to the division section instead of the calculated ratio when the threshold is larger than the calculated ratio.

According to this configuration, since the amplitude level is controlled not to exceed the predetermined upper limit, it is possible to reduce the peak power.

The present invention is applicable to a communication terminal apparatus and base station apparatus in the digital radio communication system.

The transmission diversity is thereby performed in the OFDM-CDMA communication, then a branch providing the larger amplitude is selected for each subcarrier signal at the time of reception, and the selected subcarrier signals are only transmitted for each branch at the time of transmission. Therefore it is possible to decrease the amplitude difference between subcarrier signals, maintain the orthogonality between spreading codes, and improve the transmission efficiency in the multipath environment.

A transmission diversity method according to the present invention has the reception step of receiving radio signals comprised of a plurality of carrier signals, subjected to frequency division multiplexing, from each of a plurality of branches, calculating received amplitude levels for each carrier signal in all the

branches, detecting a branch providing the largest received amplitude for each carrier signal, and despreading a received signal from a detected branch with a predetermined spreading code for each carrier signal to obtain data, and the transmission step of spreading a plurality of transmission data with respective different spreading codes, and performing the frequency division multiplexing using the plurality of carrier signals to transmit for each carrier from a selected branch.

According to this method, by selecting branches each providing a larger received amplitude for each subcarrier at the time of reception, and transmitting only subcarriers selected for each branch at the time of transmission, the amplitude deviation in subcarrier received signals is decreased, and thereby it is possible to maintain the orthogonality between spreading codes, and to prevent the transmission efficiency from being lowered in the multipath environment.

The transmission diversity method according to the present invention further has the steps of calculating an average received amplitude level of selected carrier signals, calculating a ratio of a received amplitude level of one of the selected carrier signals to the average received amplitude level for each carrier, and dividing a transmission signal immediately before being subjected to the frequency division multiplexing by the

ratio for each subcarrier signal.

According to this method, transmission amplitude control is performed for each subcarrier signal corresponding to the received amplitude, and weighting is performed prior to the transmission with propagation path condition taken into consideration, whereby it is possible to make amplitude levels constant levels at the reception side, and therefor to decrease the received amplitude deviation.

The transmission diversity method according to the present invention further has the steps of holding an arbitrary threshold to compare a calculated ratio with the threshold, and dividing the transmission signal immediately before being subjected to the frequency division multiplexing by the threshold instead of the calculated ratio for each carrier signal when the threshold is larger than the calculated ratio.

According to this configuration, since the amplitude level is controlled not to exceed the preset upper limit, it is possible to reduce the peak power.

As explained above, according to the present invention, the transmission diversity is performed in the OFDM-CDMA communication, then a branch providing the larger amplitude level is selected for each subcarrier signal at the time of reception, the selected subcarrier signals are only transmitted for each branch at the time of transmission. Therefore it is possible to decrease

the amplitude difference between subcarrier signals, maintain the orthogonality between spreading codes, and improve the transmission efficiency in the multipath environment.

The present invention is not limited to the above described embodiments, and various variations and modifications may be possible without departing from the scope of the present invention.

This application is based on the Japanese Patent Application No.HEI11-189520 filed on July 2, 1999, entire content of which is expressly incorporated by reference herein.

What is claimed is:

1. A transmission/reception apparatus comprising:

reception means for receiving radio signals comprised of a plurality of carrier signals, subjected to frequency division multiplexing, from each of a plurality of branches;

branch selection means for calculating received amplitude levels for each carrier signal in all the branches, and detecting a branch providing a largest received amplitude for each carrier signal;

demodulation means for despreading a selected carrier signal with a predetermined spreading code to obtain data; and

transmission means for performing the frequency division multiplexing using the plurality of carrier signals to transmit for each carrier from the branch selected in said branch selection means.

2. The transmission/reception apparatus according to claim 1, wherein said transmission means comprising:

average level calculation means for calculating an average received amplitude level of selected carrier signals;

division coefficient calculation means for calculating a ratio of a received amplitude level of one of the selected carrier signals to the average received

amplitude level for each carrier; and

division means for dividing a transmission signal immediately before being subjected to the frequency division multiplexing by the ratio for each carrier signal.

3. The transmission/reception apparatus according to claim 2, wherein said division coefficient calculation means holds an arbitrary threshold, compares a calculated ratio with the threshold, and outputs the threshold to said division means instead of the calculated ratio when the threshold is larger than the calculated ratio.

4. A transmission diversity method in an OFDM-CDMA communication, said method comprising:

the reception step of receiving radio signals comprised of a plurality of carrier signals, subjected to frequency division multiplexing, from each of a plurality of branches, calculating received amplitude levels for each carrier signal in all the branches, detecting a branch providing a largest received amplitude for each carrier signal, and despreading a received signal from a detected branch with a predetermined spreading code for each carrier signal to obtain data; and

the transmission step of spreading a plurality of transmission data with respective different spreading codes, and performing the frequency division

multiplexing using the plurality of carrier signals to transmit for each carrier from a selected branch.

5. The transmission diversity method in the OFDM-CDMA communication according to claim 4, further comprising the steps of:

calculating an average received amplitude level of selected carrier signals;

calculating a ratio of a received amplitude level of one of the selected carrier signals to the average received amplitude level for each carrier; and

dividing a transmission signal immediately before being subjected to the frequency division multiplexing by the ratio for each carrier signal.

6. The transmission diversity method in the OFDM-CDMA communication according to claim 5, further comprising the steps of:

holding an arbitrary threshold to compare a calculated ratio with the threshold; and

dividing the transmission signal immediately before being subjected to the frequency division multiplexing by the threshold instead of the calculated ratio for each carrier signal when the threshold is larger than the calculated ratio.

ABSTRACT OF THE DISCLOSURE

Diversity control section 111 calculates received amplitude levels of all subcarrier signals from all branches, and selects a branch providing the largest amplitude level for each subcarrier signal. Based on the above selection result, selectors 104 are switched to transmit respective subcarrier signals from the selected branch, and selectors 112 are switched to receive respective subcarrier signals from the selected branch.

09850966 .092900

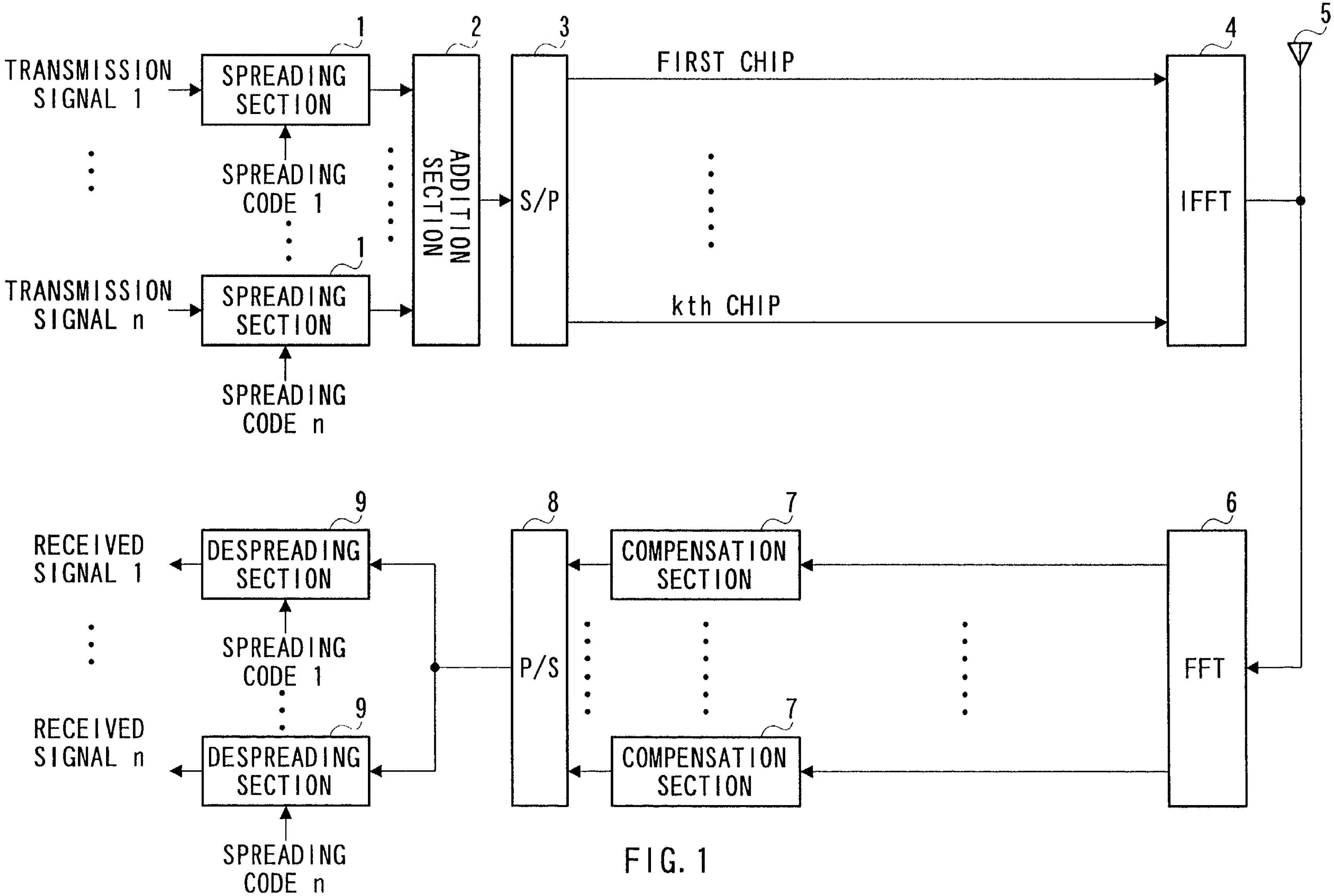
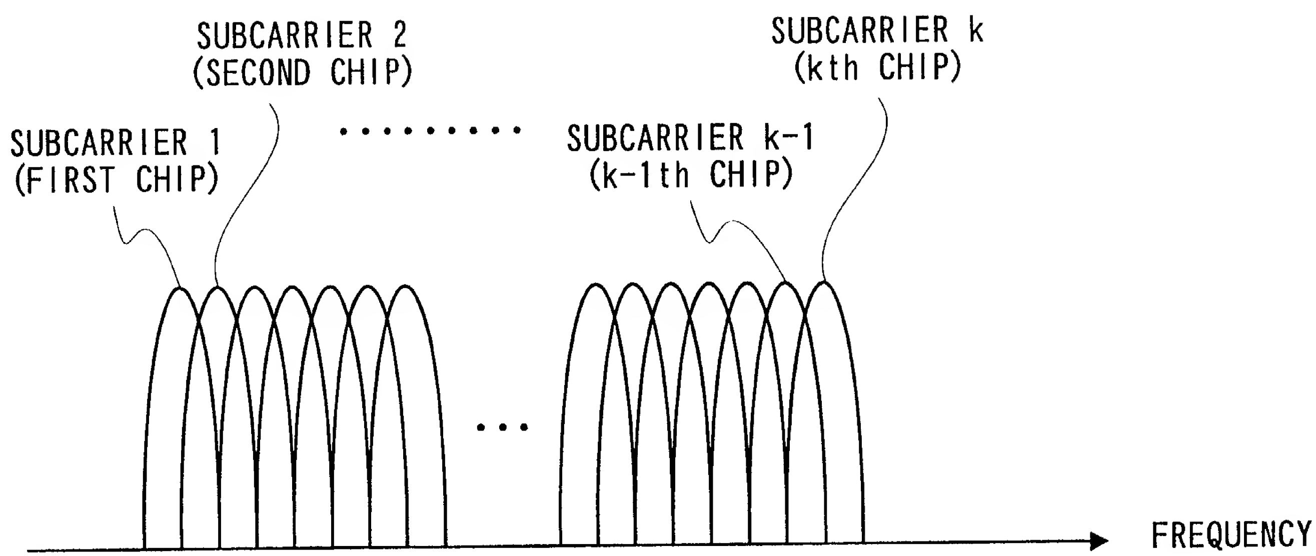


FIG. 1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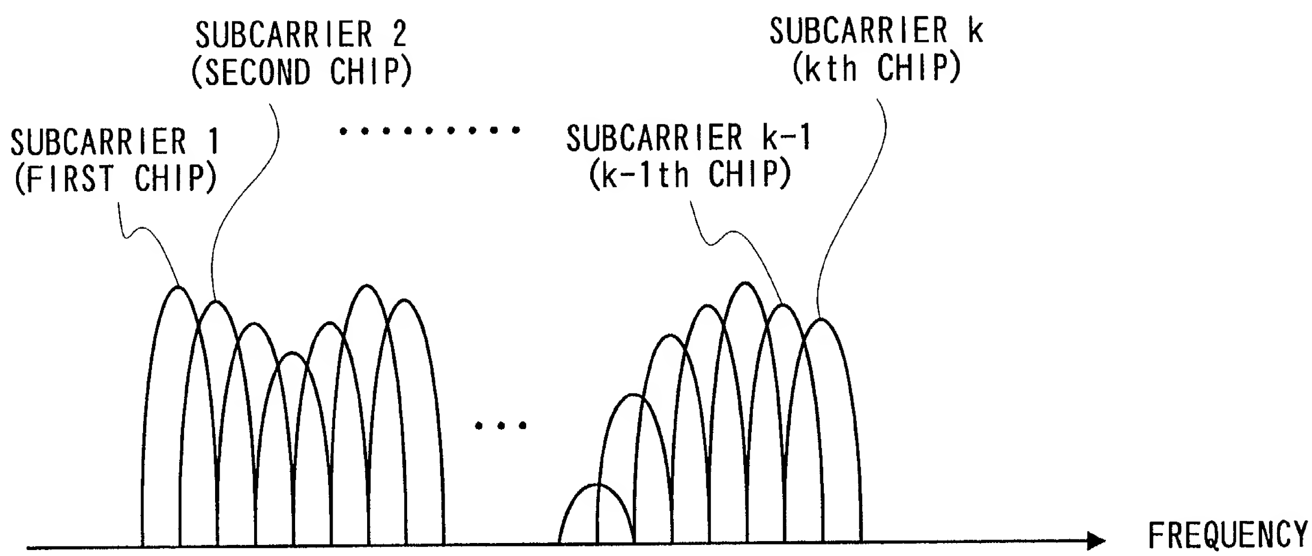
(FIRST CHIP)
SUBCARRIER 2
(SECOND CHIP)
SUBCARRIER k-1
(k-1th CHIP)
SUBCARRIER k
(kth CHIP)
FREQUENCY

FIG. 2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SUBCARRIER 2
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(k-1th CHIP)
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(kth CHIP)
FREQUENCY

FIG. 3

09650366 ˙ 052900

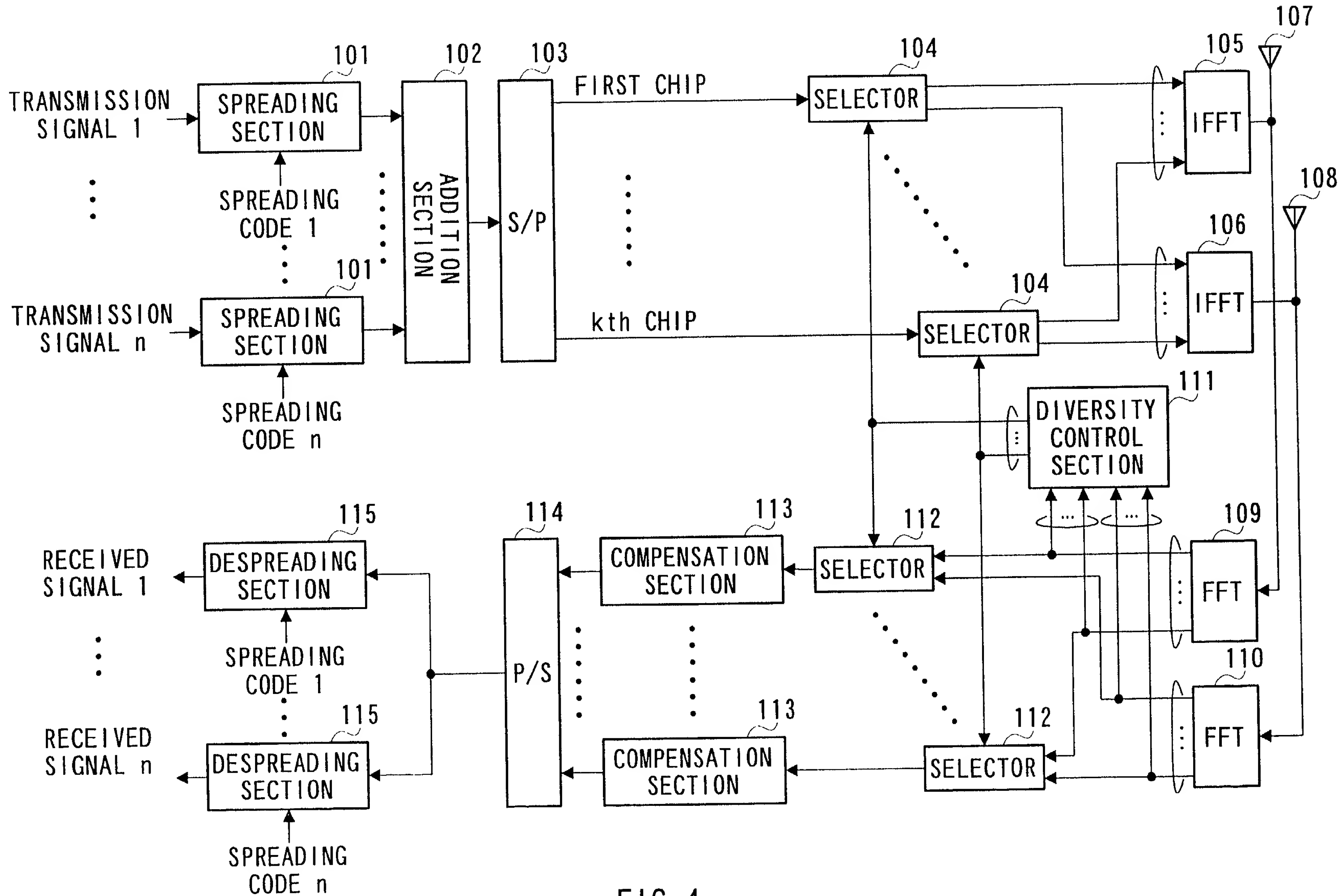
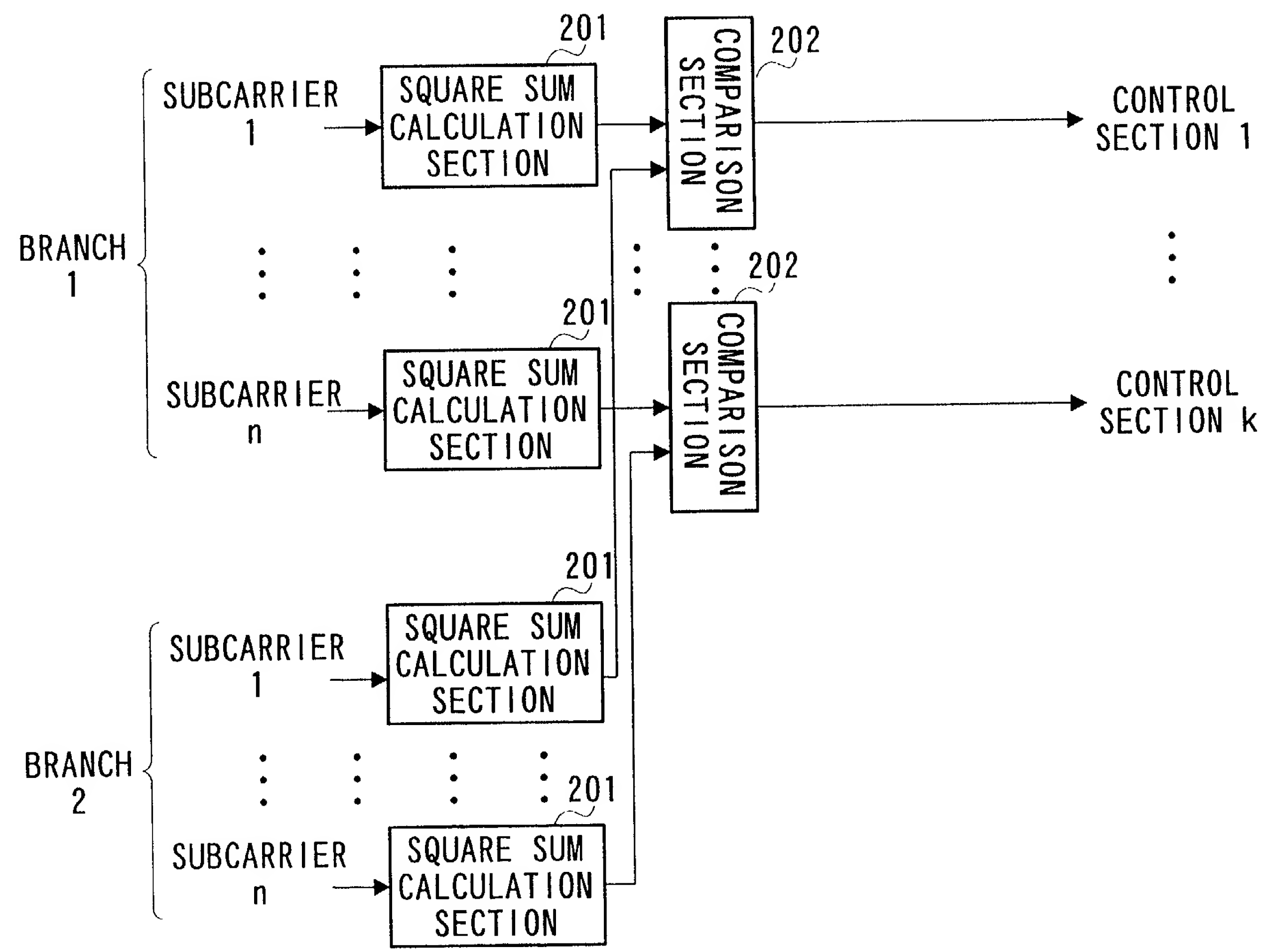


FIG. 4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202
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COMPARISON SECTION
CONTROL SECTION 1
BRANCH 1
202
201
SUBCARRIER n
SQUARE SUM CALCULATION SECTION
COMPARISON SECTION
CONTROL SECTION k
201
SUBCARRIER 1
SQUARE SUM CALCULATION SECTION
BRANCH 2
201
SUBCARRIER n
SQUARE SUM CALCULATION SECTION

FIG. 5

FIG. 6A

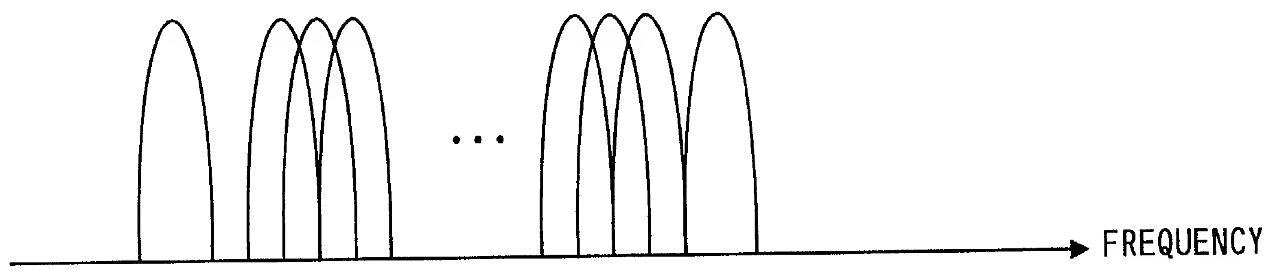


FIG. 6B

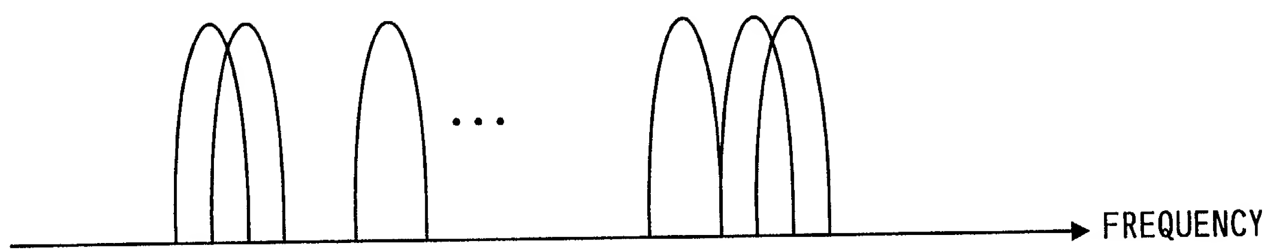
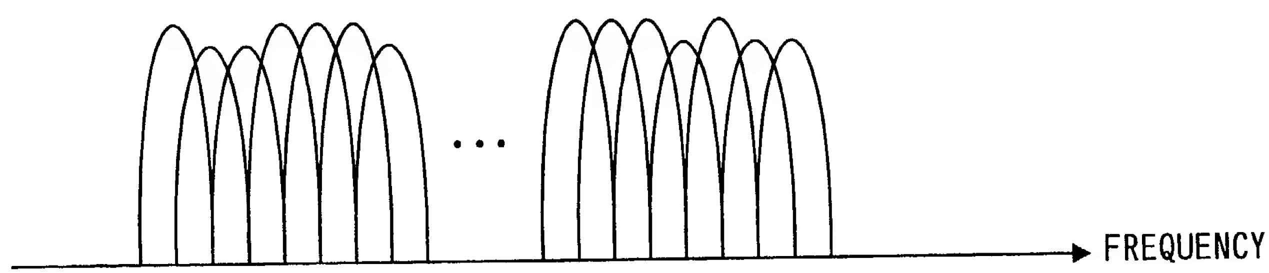
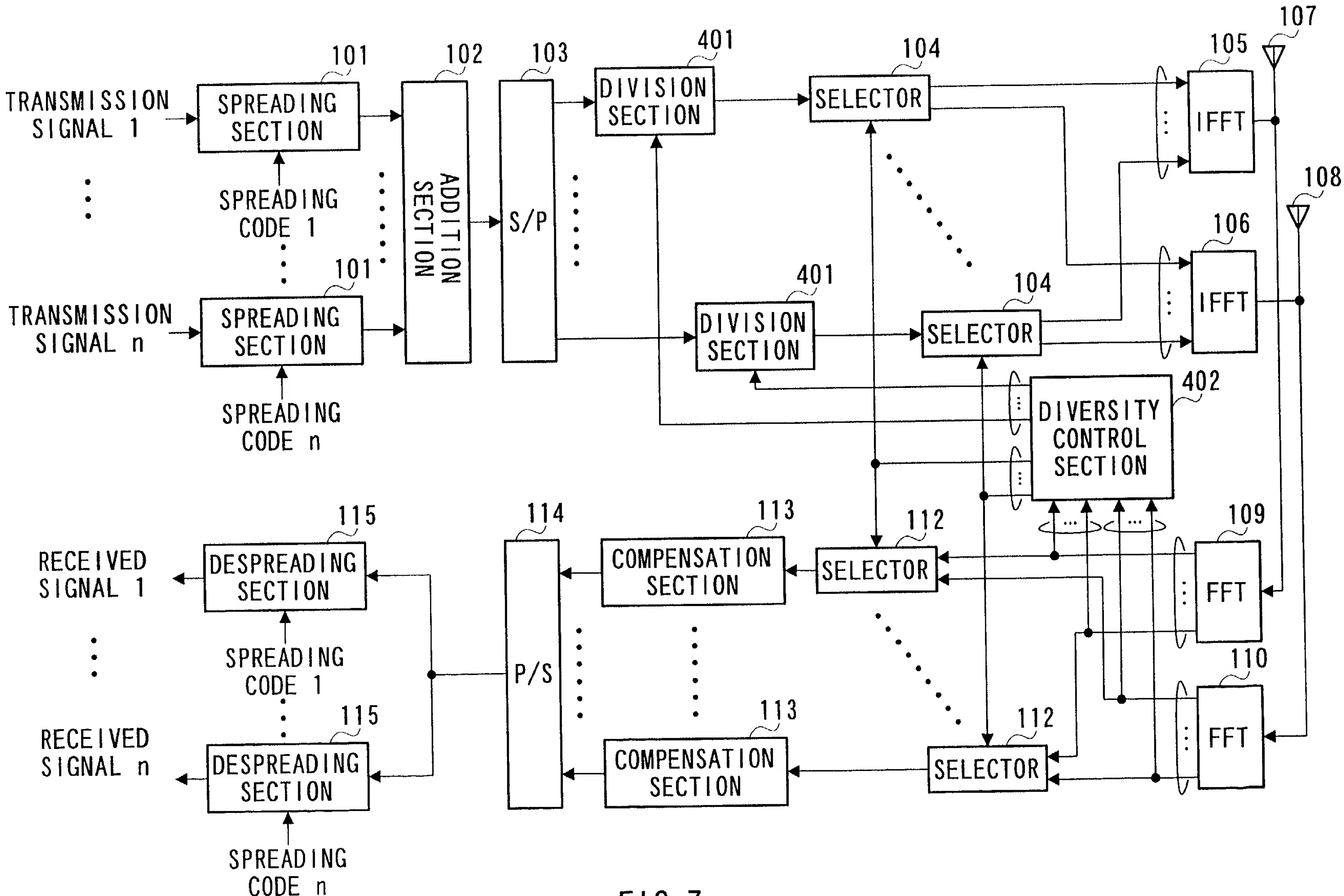


FIG. 6C





TRANSMISSION SIGNAL 1
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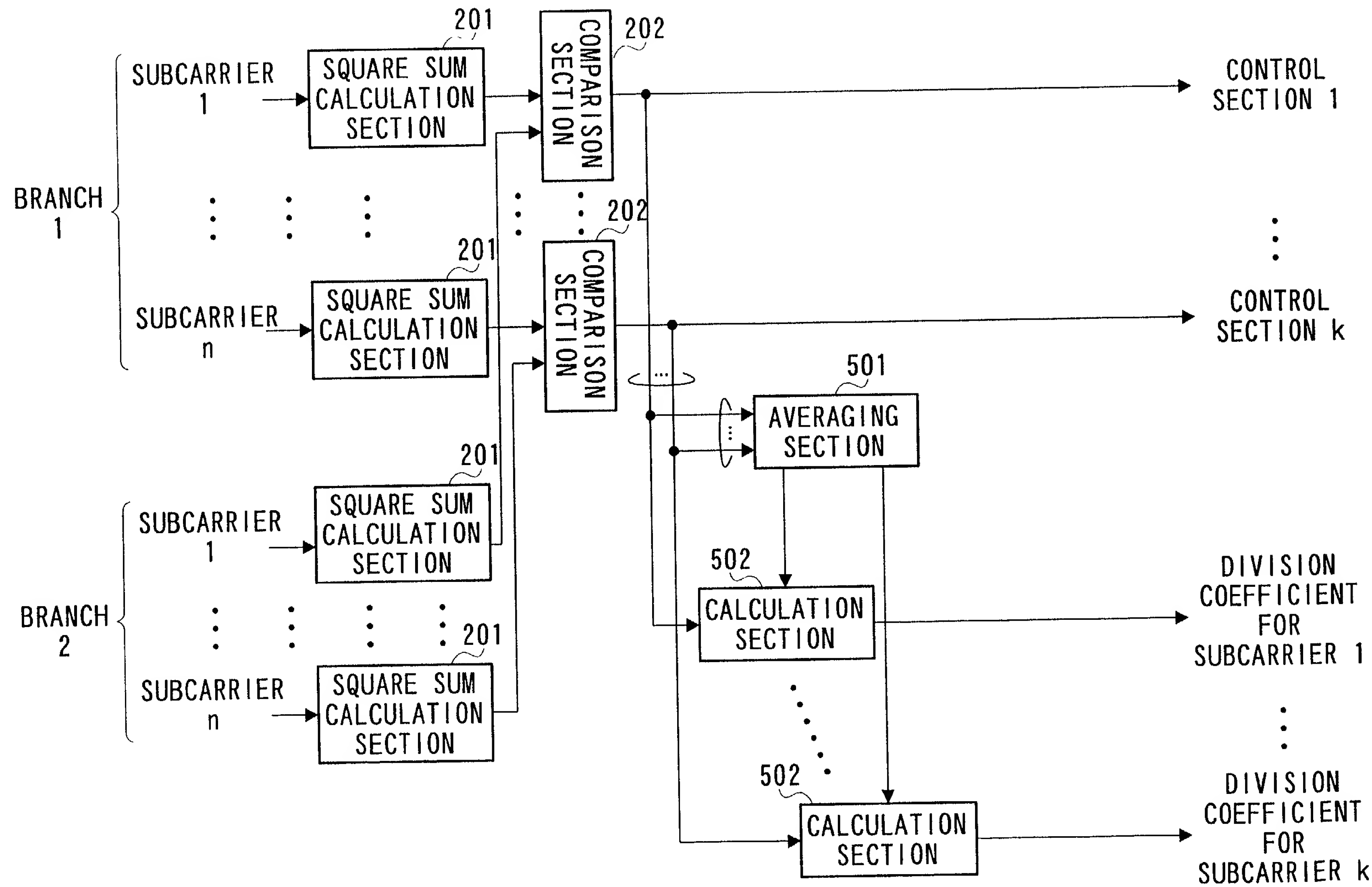
SPREADING CODE 1
TRANSMISSION SIGNAL n
SPREADING SECTION
101
SPREADING CODE n
ADDITION SECTION
102
S/P
103
DIVISION SECTION
401
DIVISION SECTION
401
SELECTOR
104
SELECTOR
104
IFFT
105
IFFT
106
107
108
DIVERSITY CONTROL SECTION
402
FFT
109
FFT
110
SELECTOR
112
SELECTOR
112
COMPENSATION SECTION
113
COMPENSATION SECTION
113
P/S
114
DESPREADING SECTION
115
DESPREADING SECTION
115
RECEIVED SIGNAL 1
SPREADING CODE 1
RECEIVED SIGNAL n
SPREADING CODE n

FIG. 7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SUBCARRIER 1
SUBCARRIER n
BRANCH 2
SUBCARRIER 1
SUBCARRIER n
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202
COMPARISON SECTION
501
AVERAGING SECTION
502
CALCULATION SECTION
CONTROL SECTION 1
CONTROL SECTION k
DIVISION COEFFICIENT FOR SUBCARRIER 1
DIVISION COEFFICIENT FOR SUBCARRIER k

FIG. 8

FIG. 9A

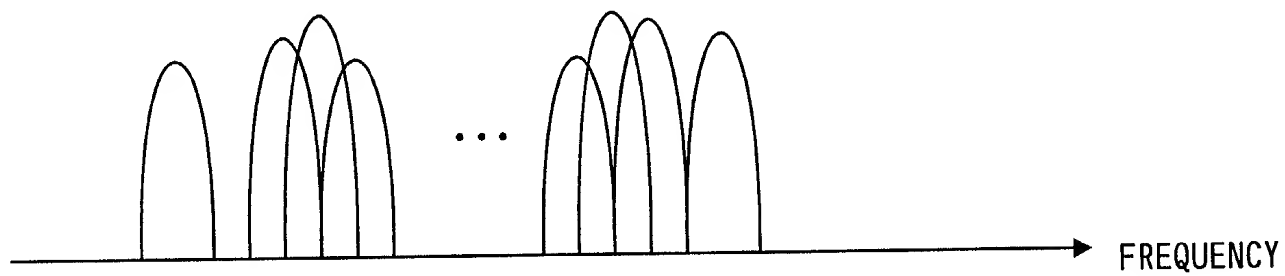


FIG. 9B

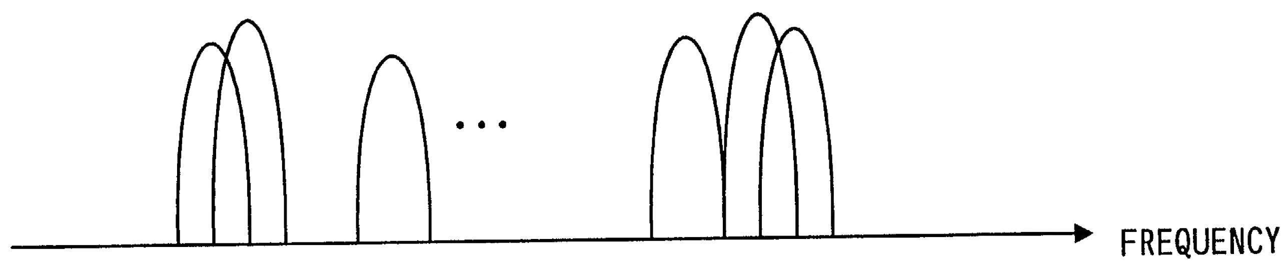
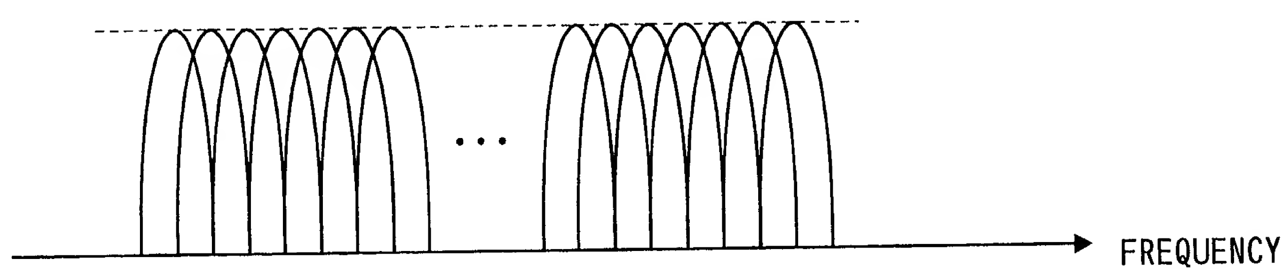
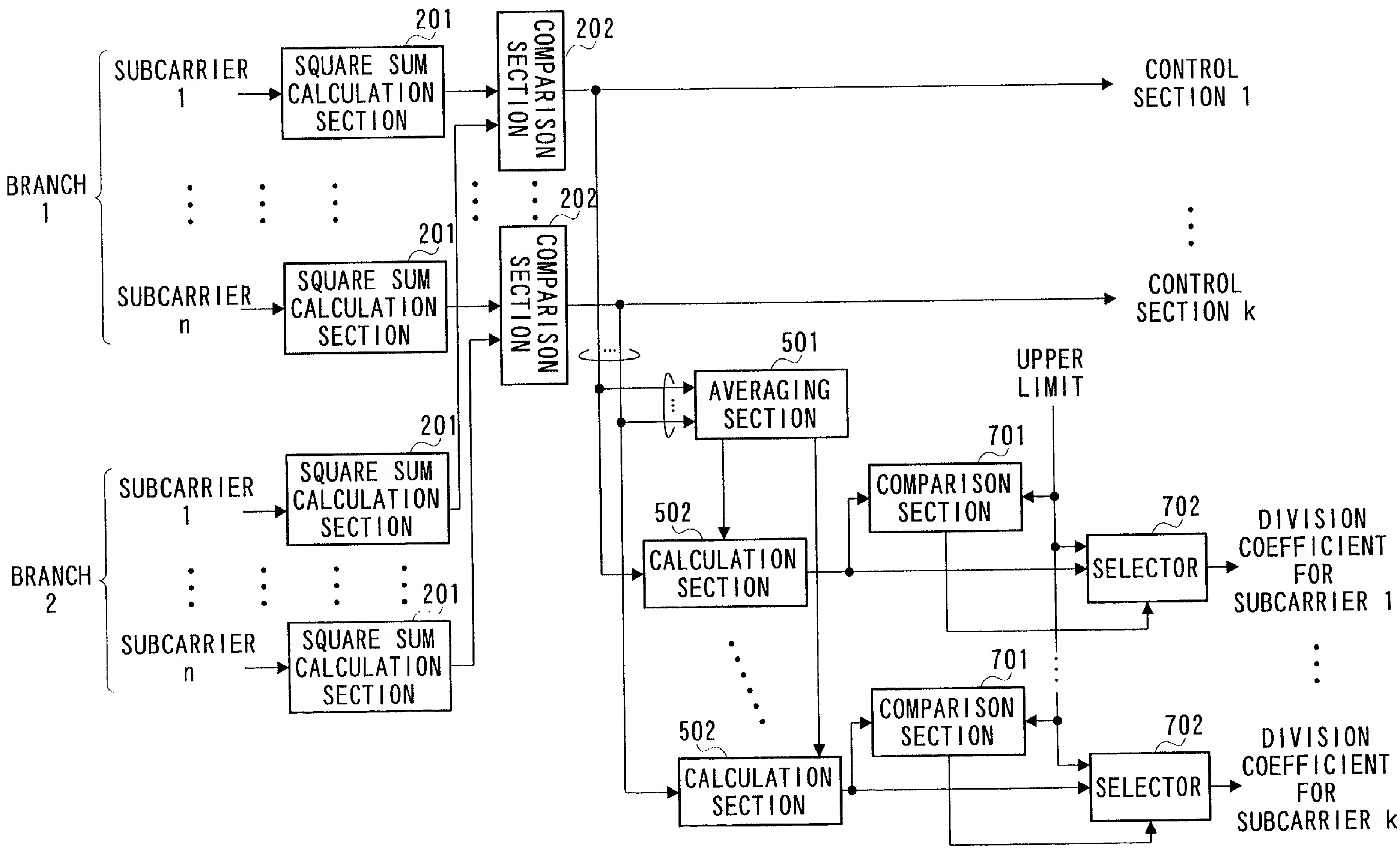


FIG. 9C





BRANCH 1
SUBCARRIER 1
SUBCARRIER n
BRANCH 2
SUBCARRIER 1
SUBCARRIER n
201
SQUARE SUM CALCULATION SECTION
202
COMPARISON SECTION
CONTROL SECTION 1
CONTROL SECTION k
501
AVERAGING SECTION
502
CALCULATION SECTION
UPPER LIMIT
701
COMPARISON SECTION
702
SELECTOR
DIVISION COEFFICIENT FOR SUBCARRIER 1
DIVISION COEFFICIENT FOR SUBCARRIER k

FIG. 10

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: TRANSMISSION/RECEPTION APPARATUS

the specification of which 2 (file no ________)

(check at least one) 3 [x] is attached hereto
4 [ ] was filed on ________ as (5) U.S. Application Serial No. ________
6 [ ] and was amended ________
(if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.		
	7 [ ]	was filed as PCT international application
	8	Number ________
	9	on ________
		and was amended under PCT Article(s) 19 and/or 34
	10	on ________ (if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119 — Priority Claimed

	(Country)	(Number)	(Day/Month/Year Filed)	Yes	No
11a	**Japan**	**H11-189520**	**02/07/1999**	[x]	[ ]
				[ ]	[ ]

[ ] Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

11b ________ ________ ________ ________
Application No. Day/Month/Year Filed Application No. Day/Month/Year Filed

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application	I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application. 13 ________ ________ ________ (U.S. Application Number) (U.S. Filing Date) Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036, TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.

See page 2 for signature lines

other side for instructions for completing this form

STEVENS, DAVIS, MILLER & MOSHER, L.L.P.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

13a	Typewritten Full Name of Sole or First Inventor	**Hiroaki** (Given Name)	(Middle Name)	**SUDO** (Family Name)
14a	Inventor's Signature	Hiroaki Hiroaki		Sudo Sudo
15a	Date of Signature	June (Month)	23, (Day)	2000 (Year)
16a	Residence	**Yokohama-shi** (City)	**Kanagawa** (State or Province)	**JAPAN** (Country)
17a	Citizenship	**JAPAN**		
18a	Post Office Address *(Insert complete mailing address, including country)*	**508, Saedo-cho, Tsuzuki-ku, Yokohama-shi, Kanagawa 224-0054 JAPAN**		
13b	Typewritten Full Name of Sole or First Inventor	Given Name	Middle Name	Family Name
14b	Inventor's Signature			
15b	Date of Signature	Month	Day	Year
16b	Residence	City	State or Province	Country
17b	Citizenship			
18b	Post Office Address *(Insert complete mailing address, including country)*			
13c	Typewritten Full Name of Sole or First Inventor	Given Name	Middle Name	Family Name
14c	Inventor's Signature			
15c	Date of Signature	Month	Day	Year
16c	Residence	City	State or Province	Country
17c	Citizenship			
18c	Post Office Address *(Insert complete mailing address, including country)*			
13d	Typewritten Full Name of Sole or First Inventor	Given Name	Middle Name	Family Name
14d	Inventor's Signature			
15d	Date of Signature	Month	Day	Year
16d	Residence	City	State or Province	Country
17d	Citizenship			
18d	Post Office Address *(Insert complete mailing address, including country)*			

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.